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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF CHEMISTRY—BULLETIN No. 95.

H. W. WILEY, Chief.

THE INFLUENCE OF ENVIRONMENT UPON THE COMPOSITION OF THE SUGAR BEET, 1903.

BY

HARVEY W. WILEY,

CHIEF OF BUREAU.

IN COLLABORATION WITH THE WEATHER BUREAU AND THE AGRICULTURAL EXPERIMENT STATIONS OF CALIFORNIA, COLORADO, INDIANA, IOWA, KENTUCKY, NEW YORK (GENEVA AND ITHACA), OREGON (UNION), WISCONSIN, AND WYOMING.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., May 25, 1905.

Sir: I have the honor to transmit for your approval a manuscript, accompanied by graphic charts, setting forth the results of the cooperative work conducted by this Bureau on the effect of environment upon the composition of the sugar beet during the year 1903. This is the fourth year of this work, the results of previous years being recorded in bulletins Nos. 64, 74, and 78 of this Bureau. The portion of the analytical work done in the Bureau on the beets was performed by Messrs. Church and Given and that on the soils by Messrs. Veitch and Trescot.

Respectfully,

H. W. Wiley, *Chief.*

Hon. James Wilson,
Secretary of Agriculture.

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ORGANIZATION OF COLLABORATIVE WORK.

Under date of January 21, 1903, the following letter of instructions was addressed to 17 experiment stations, the majority of which had taken part in this cooperative work during the three previous years:

DEAR SIR: It is desired to continue the collaborative work in the study of the influence of environment on the composition of the sugar beet. For this purpose I send you, under separate cover, seed and shipping tags, and an outline of the work in which your assistance is requested.

If, after reading the outline of the experiments, you are willing to collaborate, please advise me to that effect as soon as practicable. If you can not collaborate, return the packages of seed, etc., using the franks inclosed to transmit the packages to this office, or use the seed as you may see fit. I am very anxious that you should collaborate in these experiments, since the data, to be of value, should come from many localities representing various climates. The following is an outline of the work desired:

Plant an area not exceeding an eighth of an acre unless a larger area or a number of plats is desired for station purposes. This matter is left to your own judgment, but it is suggested that the special plat be seeded very heavily so as to assure a good stand and that enough seed be reserved for replanting in case the first planting should not germinate.

The soil, some time before sowing, preferably the previous autumn, should have been plowed to the usual depth of 8 or 9 inches and subsoiled about 6 inches more, making a seed bed at least 15 inches deep. If the character of the soil warrants it, a deeper plowing, even to 10 or 11 inches, and a subsoiling of 6 inches additional, will be advisable. The surface of the soil should be reduced to a fine tilth, well harrowed, and stirred immediately before planting so as to stop all growth of weeds.

Make the rows 18 inches apart and plant the seed at the rate of about 25 pounds per acre, so as to insure a good stand. If the soil is moist, cover the seed to a depth of one-half to 1 inch; if the weather is dry, a slightly deeper planting is advisable. The plat should be as nearly square as practicable except in the event of planting a larger area.

As soon as the plants are vigorously growing they should be "bunched" with a hoe—that is, separated into clumps by a hoe 6 inches in width, leaving the length of 3 inches of beets in each bunch. When the beets begin to form the fourth leaf they should be thinned to about one plant in each 9 inches. If the soil is very fertile the beets may be left closer together. Ordinary surface cultivation is all that is required, taking care not to cover up the beets at the first cultivation.

It is desired to make a careful analysis of the soils on which the beets are grown, and therefore you are requested to take representative samples of the soil and subsoil of the plat used for this experiment. After taking a representative sample, reduce it in size by quartering or otherwise, so as to obtain

a representative subsample weighing not more than 4 pounds. Accompanying the seed you will find bags for packing the soils, also shipping tags. Enter on the tag the name of your station, the words "Beet soil," the kind of soil, and the date. Also send a history of the plat as far as known. Complete cultural data and meteorological data, which may be obtained in collaboration with the Weather Bureau, are also desired.

One month prior to the usual time of harvest in your locality, begin harvesting beets from the experimental plat. Harvest every beet in 50 feet of an inside row, remove the leaves, clean the beets, and weigh them. Select 25 average beets, weigh them without topping, and forward them to this Bureau by express, collect. Inclose a slip in the package giving all weights and your estimate of the tonnage, based upon the weight of beets from 50 feet of row. Repeat this sampling once each week until frost prevents further operations, or, as in California, the beets begin to deteriorate.

It is urged that these directions be implicitly followed, since the outcome of the work depends upon the care and uniformity with which the agricultural work and the sampling are done. If practicable, I shall be glad to have check analyses made at your station, and during the progress of the analytical work the results obtained here will be reported to you for comparison.

The stations where irrigation is practiced were requested to report the dates of irrigation, the amount of water applied each time, and any other details relating to this special phase of the experiment.

The seed used in this experiment was furnished by the Seed Laboratory of the Bureau of Plant Industry, with the following description: Kleinwanzlebener beet seed received from E. H. Morrison, Fairfield, Wash., January 17, 1903; germination test gave 80.5 per cent of seed balls, and 161 sprouts from 100 balls.

Reports are given from only ten stations besides Washington, D. C. The data in some cases are somewhat fragmentary, but are placed on record for consideration in connection with the work of the other four years of the experiment. Several of the stations which planted the seed did not complete the work, the crop in California being a failure, while, through a misunderstanding, the necessary analytical data and samples were not received from the stations in Virginia, Michigan, and Utah, and they are therefore excluded from the report of this year's work. The stations reporting results are those of Colorado, Iowa, Indiana, Kentucky, New York (Geneva and Ithaca), Oregon (Union), Wisconsin, and Wyoming.

EXPERIMENTS CONDUCTED IN HUMID REGIONS.

POTOMAC FLATS, WASHINGTON, D. C.

Under date of July 20, Mr. Beattie, assistant horticulturist of the Bureau of Plant Industry, made the following report on the beets being grown under his directions on the Potomac Flats branch of the Arlington Experiment Farm:

The four plantings on heavy soil, made at intervals of two weeks beginning April 20 and continuing until June 1, are on this date more uniform than at

this time last year. Owing to constant cold rains the seed did not germinate well and a rather poor stand resulted from the first two plantings. The foliage now almost covers the surface of the ground and no disease is apparent. The planting made on sandy soil on April 20 made a good stand, and the beets are considerably ahead of those on the other plats.

In general the season in Washington has been very late, and, while the rainfall has not been excessive, there has been more cold, rainy weather than usual. These conditions have delayed both the planting and cultivation of the crops very greatly.

The agricultural, analytical, and meteorological data obtained for this experiment are given in the following tables, the averages being determined on 15 samples taken weekly from August 7 to November 23:

Agricultural and analytical data on beets grown on the Potomac flats, District of Columbia, showing averages for different dates of planting.

SANDY SOIL.

Number of planting.	Date of planting.	Number of beets in 50 feet of row.	Weight after topping.		Estimated tonnage.	Sugar in juice.	Sugar in the beet.	Purity coefficient.
			Total.	Average.				
	1903.		*Pounds.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
First	Apr. 20	23	49.5	34.6	12.7	8.8	8.2	69.4

HEAVY SOIL.

First	Apr. 20	47	53.9	18	13.9	8.5	7.9	70.3
Second[a]	May 4	51	57.2	18.9	14.6	9.3	8.7	71.6
Third	May 17	52	52	16.2	13.3	9.5	9	70.8
Fourth	June 1	63	41.4	10.1	10.6	9.6	9	70.5

[a] Data for the second planting on heavy soil, that of May 4, are used in the graphic charts.

Meteorological data for Washington, D. C., 1903.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	64.4	2.75	285.1	443.8	64	17	7
June	67	3.60	175	445.9	39	5	15
July	76	5.17	324.8	453	72	19	3
Averages and totals	69.1	11.52			58	41	25
August	71.8	4.52	178.4	423.2	42	8	14
September	67.2	.74	265.1	373.4	71	16	5
October	56.8	4.48	189.4	346	55	16	9
Averages and totals	65.3	9.74			56	40	28
General averages and totals	67.2	21.26			57	81	53

The soil on which the beets were grown on the Flats, as has been mentioned in previous reports, has been made artificially by dredging the channel of the Potomac River. The method of dredging consists in pumping the mud from the bottom of the river, and the water mixed therewith, through pipes, collecting the mixture in ponds,

allowing the mud to settle, and removing the water either by drainage or by allowing it to percolate naturally through the soil or to evaporate. In some parts of the field, therefore, the surface is covered with sand, more or less pure, while in other sections the made soil consists of clay, organic matter, and more or less sand.

During the present season comparative determinations were made on the quantity and quality of the beets produced on the sandy soil and on the heavier soil just described. Only one planting was made on the sandy soil which may be compared with the planting made on the same date on the heavy soil. The yield on the heavy soil was a little over 1 ton more per acre than upon the sandy soil; the percentage of sugar in the beet was 0.3 per cent less, and the purity 0.9 higher. The later plantings on the heavier soils, however, show more favorable data. In all cases in the later plantings the percentage of sugar in the beet is greater and the purity higher than for the first planting. The yield per acre varied, being greater than the first planting on the plat seeded May 4 and less on the other two plats.

The rainfall was well distributed, though considerably more abundant in July than in May and somewhat too heavy in October. The general seasonal conditions were fairly good, but the yield was considerably less than in the previous year. The general character of the beets is practically the same as for the three preceding years, the most striking characteristics being low sugar content and purity.

THE INDIANA STATION.

A very complete report was received from Mr. W. J. Jones, jr., in charge of the beet work at the Indiana station, both on the general experiment and on a separate study that was made in comparing an irrigated and an unirrigated plat. The cultural data from the preparing of the soil in March to September 25 are as follows:

CULTURAL DATA.

March.—Plat plowed and harrowed.

May 1.—Plat harrowed both ways. Soil and subsoil sampled.

May 2.—Soil broken with clod crusher. Beets sown in the morning. Soil in excellent condition; temperature of soil 62° F. Area first planted, 71.5 by 296 feet; 13 pounds of seed used in planting and replanting. Part of the plat was planted in rows 18 inches apart and the remainder in rows 22 inches apart.

May 9.—Beets beginning to come through.

May 12.—Beets practically all up; apparently a good stand.

May 17.—Close examination reveals absence of beets in many places. Ungerminated seed found in soil.

May 18.—Plat resown where beets were thin.

May 28.—Resowing appears to have been of little value and stand is scattering.

June 2.—Beets transplanted to fill in rows. Most of rows planted 18 inches apart were so poor that they were abandoned and the experiment was continued with the rows which were planted 22 inches apart.

June 9–10.—Beets hoed and weeds removed. Grubworms at work in field.

June 17.—Beets thinned to distance of about 9 inches. Owing to transplanting it was difficult to get uniform distance.

June 25.—Beets cultivated. Plants look fine. Soil in excellent condition.

July 8.—Beets cultivated. Beetles working on leaves of plants. Foliage abundant. Plants in excellent condition.

July 17.—Soil loosened with plow and drill attachment. Weeds removed with hoe. Potato bugs in field.

August 3–24.—Beets making good progress. Plat free from weeds and soil in good condition.

August 24.—Beet leaves turning yellow in places.

August 31.—Leaf disease (Huston's Evil Eye) making its appearance. Leaves turning brown and wilting.

September 8.—Beets wilting. Leaf disease increasing.

September 12.—Plants sprayed with Bordeaux mixture.

September 14.—Beets maturing. Sample gave 12.8 per cent sugar in the juice.

September 21.—Sample gave 12.8 per cent sugar in the juice.

The foregoing applies not only to the plats which were cultivated without irrigation, but also to those on which the irrigation experiment was conducted.

The following additional comments relate to watering on the irrigated plats, and give comparisons of the irrigated and unirrigated crops:

July 1.—Rows ridged and hollows left for irrigation.

July 2.—Water equivalent to 1.63 inches was added to the entire plat. The plat was 77.5 feet by 18.3 feet, and required the addition of 118.4 cubic feet of water for each inch of depth.

July 9.—Water equivalent to 0.66 of an inch was added to the entire irrigated plat. The ground absorbed water rapidly. Both ground and beets are in excellent condition.

August 3.—Water equivalent to 1 inch was added to the entire field. This addition made the ground very wet. Beets in unirrigated plat look better than beets in irrigated. Lower leaves of beets in latter are turning yellow.

August 10.—Irrigated beets wilt during heat of day. Leaves drying up.

August 17.—Beets about as at last report.

August 24.—Beets making progress. Unirrigated look better than irrigated. Leaves of irrigated beets turning badly. Bugs in field.

August 31.—"Huston's Evil Eye" making its appearance. Irrigated beets are worst affected.

September 8.—Irrigated beets are showing bad effects of "Evil Eye."

September 12.—Entire field was sprayed with Bordeaux mixture.

REPORTS DURING THE HARVEST.

With each sample of beets sent from September 25 to November 29 full reports were made as to the condition of the crop, extracts from which are given below:

September 29.—We have had a great deal of difficulty with the cooperative beet experiments this year, due to two causes: (1) The plat on which we have been raising these beets does not seem to be in good condition for such a purpose, and (2) the seed did not germinate well. For this reason our plants were scattering, and it was necessary for us to transplant a large number. Those

which were transplanted are not perfect in form, having a tendency to multiplicity of roots. For this reason it is very questionable whether we can give a fair estimate of the yield.

October 4.—The plants are looking very well at present, and the leaf disease noted in previous years seems to have been checked. As yet we have found no beets affected with this disease, and they are also free from scab. The tendency to root multiplication mentioned in the last report does not seem to be due to transplanting, as was suggested, since the same defect is noticed in parts of the field where no beets were transplanted. Rains of over 1 inch during the past week will have a tendency to retard the maturing of the beets.

October 9.—While the beets are looking very well indeed, the weather since the taking of the previous sample has been unfavorable to maturing them. During the last week we had rain on five days, 2.1 inches falling. The weather has been cold and the days cloudy, so that the beets, instead of progressing, have really gone backward. The prospects at present are more favorable, as the sun has been shining all day, although it is still cold.

October 16.—The early part of the past week was rather more favorable for the ripening of the plants, as the days were clearer and the sun shining. However, before the moisture which fell the previous week had been absorbed it began to rain again, and during the past three days there has been a total rainfall of 0.49 inch. The beets are therefore making a second growth. The light frost the first part of the week did not seem to materially affect the ripening of the beets. Unless the crop ripens soon we shall have to cut the sample down to 25 feet, since the amount we have on hand will not permit the sending of any more samples from 50 feet.

October 24.—The weather during the first part of the past week continued to be unfavorable to ripening, and many of the plants have started a second growth of leaves. The weather for the past four days, however, has been such that this growth should be checked. The plants are looking very well and conditions are favorable.

October 29.—The weather of the past week has been much more favorable for the ripening of the beets. The days have been clear and cool, there being frost on five days and a temperature below freezing on four days. All the days have been full of sunshine.

November 6.—The weather of the past week on the whole has been rather more favorable for ripening the beets, and, while the majority of the days have been cloudy, the sun has shone about half the time. We have had two very heavy frosts and 0.19 inch of rainfall. The field as a whole looks well.

In the sample sent you on November 5, I also inclosed four beets of the character mentioned in my previous letter, i. e., having many roots. We find this type of beets more frequently in the part of the field to which it was necessary to transplant, but the beets sent with the sample are from a portion of the field to which no beets were transplanted.

We have followed the suggestion of Professor Huston and irrigated a portion of this field. The method of procedure was to apply each week enough water to make 1 inch when combined with the rainfall. This experiment was conducted on 10 rows of beets, 75 feet long, the last water being applied on August 3. It was necessary, in order to have the water applied equally, to ridge these 10 rows and, for purposes of comparison, 10 rows were also ridged to which no water was applied. It was a very noticeable fact that the beets which were irrigated wilted much more rapidly than those not so treated, and the irrigated section of the field is not reaching maturity as rapidly as the other portion.

November 14.—The weather of the past week has been more favorable for ripening the beets. Since sending the last sample we have had three cloudy days

and five clear days, with heavy frost on four days. The last three days have been cloudy and rainy, and yesterday about 1 inch of snow fell. The total rainfall for the week is 0.47 inch. To-day the weather has been slightly warmer. If the weather should continue favorable, the beets should reach a maximum in the next sample.

November 23.—Following the rain of the 17th the weather became suddenly much colder and the ground froze to about a depth of 3 inches on the 18th. The beets sampled on the 19th were frozen somewhat, but we tried to secure a sample that would be representative and not show the effects of the freezing. In estimating the yield of these plats I think the sample just sent may be taken as representative and that the yield per acre calculated upon this basis will not be far from right. The beets in all the plats from which samples have been sent you were planted in rows 22 inches apart.

ANALYTICAL DATA.

The following analytical data, determined both at the station and at Washington, show the results obtained on the irrigated and unirrigated plats, and the climatic conditions under which the experiment was made:

Agricultural and analytical data on beets grown at Lafayette, Ind., and forwarded to Washington, D. C., 1903.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 28	11.5		13.3	12.1	82.6
October 6	12.1		15	13.9	83.3
October 13	14		14.7	13.4	87
October 21	19.2		13.3	12.5	83.4
October 30	15.3		13.5	12.9	77.6
November 4	16.2		13.1	12	75.3
November 11	13		15.2	14.1	82.6
November 18	16.4		15.5	14.3	80.7
November 25 [a]	16.4		15	13.8	82
November 25 [b]	19.2		14.3	13.2	80.3
November 25 [c]	19.2		13.4	12.5	78.8
Average	14.9	[d] 8.9	14.3	13.2	81.6

[a] From same plat as previous samples.
[b] From plat for comparison with irrigated—excluded from average.
[c] From irrigated plat—excluded from average.
[d] Estimated from station data, capped beets.

Agricultural and analytical data on beets grown at Lafayette, Ind., determined at the Indiana Station, 1903.

Date of sampling.	Number of beets in 50 feet of row.	Total weight of beets.	Average weight of beets.	Estimated yield per acre.[a]	Lost in capping.	Net yield per acre.[a]	Sugar in juice.	Sugar in beet.[a]	Purity coefficient.
1903.		*Pounds.*	*Ounces.*	*Tons.*	*Per cent.*	*Tons.*	*Per cent.*	*Per cent.*	
September 25	47	44	15.1	9.3	34.4	6.1	12.8	11.8	83.6
October 1	62	52	13.3	11	12.2	9.7	14.6	13.4	85.4
October 8	48	47.8	15.8	10.1	22.4	7.8	14.2	13.1	86
October 16	44	55.3	20	11.8	5.7	11.1	13.5	12.4	85.7
October 23	41	51.1	20	10.8	18.6	8.8	13.5	12.4	82.8
October 29	39	47.1	19.3	10	18.1	8.2	14.6	13.4	88.6
November 5	55	46	13.3	9.8	18.4	8	14.7	13.5	86.1
November 13	52	65.5	20.1	13.4	21.4	10.5	14.7	13.5	81.5
November 19	46	59.8	20.7	12.8	20.1	10.2	14.7	13.5	84
Average	48	52.1	17.5	11	19	8.9	14.1	13	84.9

[a] Calculated at Washington, D. C.

Comparison of beets grown on irrigated and unirrigated plats as reported by the station, 1903.

Date of sampling.	Irrigated.		Unirrigated.		Irrigated.	Unirrigated.
	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Yield per acre.	Yield per acre.
	Per cent.		*Per cent.*		*Tons.*	*Tons.*
September 14	12.1	85.2	11.4	87.7		
September 21	12.3	86	11.7	75.8		
October 1	13.9	85.3	14.5	85.3		
October 8	12.3	87.2	14.5	88.3		
October 23	12.1	80.5	13.4	85.4	6.5	8.3
October 29	14	89.2	14.4	92.9		
November 5	13	82.7	13.9	82.6	9.9	9.1
November 13	13.6	82.1	13.6	80.5	4.9	9.7
November 19	13.5	83.8	13.5	85.5	9.1	8.9
Average	12.9	84.9	13.4	85	7.6	9

Meteorological data for Lafayette, Ind., 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	65	2.71	9	21
June	65.8	2.37	11	17
July	74.2	2.68	16	13
Average and totals	68.3	7.76	36	51
August	71.6	5.05	12	16
September	65.4	1.96	17	12
October	53.4	2.58	17	10
Average and totals	63.5	9.59	46	38
General average and totals	65.9	17.35	82	89

Sunshine record for Indianapolis,[a] Ind., 1903.

Month.	Sunshine.		
	Actual.	Possible.	Percentage.
	Hours.	*Hours.*	
May	231.7	446.7	52
June	211.9	449	47
July	278.4	455.2	61
Average			53
August	224.5	425.2	53
September	255.1	373.6	68
October	224.4	344.9	65
Average			62
General average			58

[a] Fifty-nine miles southeast of Lafayette.

The very complete data from the Indiana Station show in a satisfactory way the general effect of the environment as a whole upon the character of the crop. The factors of the environment which most concern us in the present discussion are temperature, rainfall, altitude, and sunshine. The analytical data obtained at the station

agree very well with those obtained on the beets sent to Washington. The analyses made in the Bureau of Chemistry show a slightly higher content of sugar, but a somewhat lower coefficient of purity, than those obtained at Lafayette. From this and previous data received from the Indiana Station it appears that the purities obtained at that point are uniformly higher than those determined on the beets received from that station by this laboratory.

The beets at the Indiana Station were of a very satisfactory size, weighing on an average 14.9 ounces; but the yield was only 8.9 tons per acre. The data on the composition of the beet—i. e., 13.2 per cent of sugar in the beet and purity coefficient of 81.6—are unusually satisfactory. The influence of the various factors of the environment have been sufficiently described in the station report. It is evident that the principal determining factor, which shows its constant influence season after season, is the temperature; and the conditions which determine the temperature are largely latitude and altitude. In fact, it becomes more and more evident, as a study of these data proceeds, that the principal influence exerted by the other features of the environment is largely through the modifications which they produce in the temperature conditions. The hours of sunshine may perhaps be an exception, but even the good effects of long-continued sunshine may be counterbalanced by the tendency to raise the temperature during the growing season.

A comparison of the data obtained under irrigation with those secured under ordinary conditions is made possible by the figures furnished by the Indiana Station. The yield per acre on the irrigated plats was 7.6 tons and on the unirrigated 9 tons. This is rather a surprising contrast, showing the unexpected depressing influence of the irrigation upon the yield. The percentage of sugar in the juice was also lower in the beets from the irrigated than from the unirrigated plats, though the difference was only 0.5 per cent, while the purities were practically the same, being only 0.1 lower in the case of the samples from the irrigated plats. In general, it is seen that the practice of irrigation, at least under the other conditions which prevailed during the season, was injurious both to yield and quality.

THE IOWA STATION.

From the Iowa Station Mr. G. I. Christie, the soil assistant in charge of the experiment, reported, under date of July 20, as follows:

The stand of beets is good, considering the season. The ground on which the beets are being grown was fall plowed and cultivated early in the spring, thereby placing it in good condition. At the time of sowing the ground was very loose, and to prevent sowing too deeply and to make a firm seed bed it was rolled.

The seed was sown May 13, in rows 18 inches apart, at the rate of 22 pounds per acre. The seeding was followed by a light shower of rain, which caused

the seeds to germinate in a few days. When the beets were coming up there was a long period of wet weather, during which heavy rains fell, and the ground baked very hard, necessitating considerable work to save the crop. The beets were cultivated, bunched, and thinned when about 3 inches high. Since then they have been hoed twice, care being taken to remove all the weeds and any doubles which might be present. At the present time the beets are growing very rapidly and have attained good size.

With the samples of beets received on October 6 the following weight estimate was sent: The weight of the 25 beets sent is 45 pounds; the weight of the beets taken from 50 feet of a row is 65 pounds. On this basis the tonnage per acre equals 15.5 tons.

The data determined on the samples received at the Washington laboratory are given in the following table:

Agricultural and analytical data on beets grown at Ames, Iowa, and forwarded to Washington, D. C., 1903.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 14	17.4	15.5	15.7	14.5	85.3
October 21	14.7	.....	15.1	15.7	77
October 30	7.6	.....	17.3	16.3	83.1
Average	13.2	15.5	16	15.5	81.8

The data from the Iowa Station are somewhat meager for this season. The average yield of beets per acre, according to the one estimation made, is 15.5 tons, and the average weight of the beets 13.2 ounces, showing that the beets were somewhat undergrown. For agricultural purposes—that is, for the proper compensation of the farmer—the beets should average over 1 pound in weight. The sugar content of the beets was very satisfactory, averaging 15.5 per cent, and the purity was reasonably high—i. e., 81.8.

The meteorological data show an average temperature for May, June, and July of 66.8°; for August, 69.4°; for September 60.5°, and for October, 51.6° F. The average temperature for the whole season, from May to October, inclusive, was 63.6° F. The precipitation was not very evenly distributed, being excessive in May and July and below the average in June, September, and October, the deficiency in the two latter months being distinctly favorable to the best development of the beet. On the other hand, the excessive precipitation in May must have influenced unfavorably the planting and germination of the seed, notwithstanding the efforts made by the agriculturist to prevent injury to the crop. The general average of the amount of sunshine is perhaps a little below the normal—i. e., 60 per cent—for the entire season. As has been shown, however, in a previous report,[a] the direct rays of the sun do not seem to be neces-

[a] U. S. Department of Agriculture, Bureau of Chemistry, Bul. No. 78, p. 42.

sary to the maximum development of sugar, as the luminous rays, which particularly influence growth, apparently pass with undiminished vigor through the clouds.

Meteorological data for Ames, Iowa, 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	°F.	*Inches.*		
May	62.3	9.46	15	9
June	64.8	1.97	14	4
July	73.4	4.77	20	3
Average and totals	66.8	16.20	49	16
August	69.4	3.70	17	4
September	60.5	1.46	16	6
October	51.6	1.07	23	3
Average and totals	60.5	6.23	56	13
General average and totals	63.6	22.43	105	29

Sunshine data for Des Moines, Iowa, 30 miles south of Ames, 1903.

Month.	Sunshine.		
	Actual.	Possible.	Percentage.
	Hours.	*Hours.*	
May	256.3	451.9	57
June	279.5	456.2	61
July	324.9	461.8	70
Average			63
August	249.9	429.4	58
September	192.8	374.5	51
October	220.6	342.5	64
Average			58
General average			60

THE KENTUCKY STATION.

The season of 1903 was very unfavorable and the beet crop suffered both in quantity and quality, as is shown by the analytical and agricultural data given in the table. The beets were grown, as usual, on a rich loamy soil that had been thoroughly plowed and subsoiled to a depth of 16 to 20 inches. Before planting, the earth was pulverized and put in perfect tilth by harrowing and rolling. On May 9 the seed was planted, and a good stand was obtained by May 16. On May 27 the plants were thinned to one or two plants every 3 inches and on June 6 to one plant every 9 inches. Three cultivations were given—on June 6 and 20 and July 6—by running a hand cultivator twice in the row and afterwards hoeing the plants. The ground was kept loose by repeated shallow cultivation. Twice during the growing season it was necessary to spray with arsenate of lead on account of the blister beetles.

The data obtained in regard to this season's work are as follows:

Agricultural and analytical data on beets, grown at Lexington, Ky., and forwarded to Washington, D. C., 1903.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*[a]	*Per cent.*	*Per cent.*	
July 24	6.8		11.1	10.2	69.9
August 7	12		8.6	7.9	71.2
August 20	15.2		10.1	9.3	74.3
August 29	10.4		10.2	10	71.3
September 9	13.2		11.4	10.5	73.5
September 28	13.9		9.7	8.9	71.8
Averages	11.9	6.25	10.2	9.5	72

[a] Tonnage reported by station.

Meteorological data for Lexington, Ky., 1903.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	°F.	*Inches.*	*Hours.*	*Hours.*			
May	67.7	1.75	296.4	441.7	67	9	6
June	67.7	2.71	176.9	443.1	40	9	12
July	76.6	2.62	292.3	450.1	65	14	5
Averages and totals	70.7	7.08			57	32	23
August	74.4	1.49	264.7	422.1	63	13	6
September	69.8	.81	291	373	78	21	3
October	56.9	2.12	222.7	347.3	64	14	6
Averages and totals	67	4.42			68	48	15
General averages and totals	68.8	11.50			62	80	38

Although the conditions in Kentucky are described as distinctly unfavorable, the quality of the beets produced was not very greatly inferior to that of previous years. The yield per acre, however, was extremely low, being reported as 6.25 tons by the station. The sugar in the beet was equal to 9.5 per cent and the coefficient of purity was 72.

The meteorological data show that the total amount of precipitation from May to October, inclusive, was deficient, and only its very even distribution made it possible to grow a crop at all. The heaviest precipitation in any one month fell in June, viz, 2.71 inches, and the smallest in September, 0.81 inch. This small rainfall in September was distinctly favorable to the ripening of the beets. The average temperature for the three months ending with July was 70.7° F., the highest temperature in any one month was that for July, viz, 76.6° F., and the next highest for August, 74.4° F. The mean temperature for the months of June, July, and August, as will be seen, is above 70° F., a condition distinctly unfavorable to the development of a high sugar content. The percentage of sunshine was 62, not an excessively

high amount. The number of clear days was more than double that of the cloudy days. It is evident, therefore, that the growing beets were subjected to rather an excessive amount of direct sunshine as well as influenced by the high temperature. With a more abundant precipitation the temperature conditions would have been favorable to an excessively large crop, but of course with a diminishing content of sugar.

THE NEW YORK STATION AT GENEVA.

Owing to a severe drought it was impossible to prepare the ground intended for the beet work of 1903, so a change was made to a field which had been intended for alfalfa. The ground had been plowed from 11 to 12 inches deep just before sowing the beets, but not subsoiled.

The seed was sown on May 28 with a hand wheel seeder. Vegetation was retarded until June 15, as practically no rain fell from April 17 to June 11. A very even stand was secured, however. Cultivation was begun on July 6, and continued at intervals of from 10 to 12 days until the middle of August. The beets were thinned on July 8 to from 8 to 10 inches in the row. The only injury to the plants observed during their growth was a slight cutting of the leaves by hail on July 20, but the yield did not seem to be appreciably affected by this. At this time the beets were growing rapidly and had from 6 to 12 leaves to each plant. The crop was harvested on November 10, 1903.

In addition to the data given above the following agricultural and analytical data were reported by Mr. G. W. Churchill, and as no samples were forwarded to the Bureau of Chemistry these data constitute the entire record:

Agricultural and analytical data on beets grown at Geneva, N. Y., determined by the station at harvest time, 1903.

Weight of 50 beets.		Average weight capped.	Yield per acre.	Sugar in juice.	Sugar in beet.	Purity.
Topped.	Capped.					
Pounds. 45.5	*Pounds.* 36.25	*Ounces.* 11.6	*Tons.* 15.6	*Per cent.* 18.2	*Per cent.* 14.2	89.4

Two hundred analyses of individual beets which were selected by the appearance of the tops before digging gave an average percentage of sugar in the beet of 14.6. The difference of 4 per cent between the sugar in the juice and that in the beet (the latter having been determined, not calculated) remains unexplained.

The average data for the Geneva Station show a good yield per acre—15.6 tons—with, however, a somewhat too small average weight, viz, 11.6 ounces. The meteorological conditions during the early periods of growth were extremely unfavorable, and for the first

time during the series of observations the beets at Geneva failed to maintain their record of having the largest content of sugar. The purity of the juice, however, is extremely high. When the yield per acre and the purity of the juice are taken into consideration, it is seen that the Geneva crop is perhaps the best for sugar making of all the beets harvested during this year's experiment.

During May, when it was necessary to prepare the seed bed and plant, there was almost no rainfall at all. The entire area of the State of New York was subjected to a drought of unusual severity and prolongation. This month of excessive drought was followed by a very heavy rainfall during June, and again in August, while the amount of precipitation during the month of September fell to 1.3 inches. Again, in October, there was an excessive amount of precipitation, which must have interfered to a serious degree with the harvest and tended to induce a vigorous second growth. An inspection of the rainfall data shows the extremely irregular distribution of the precipitation. The temperature data show most favorable conditions for the growth of a beet high in sugar. During only one month was the average temperature above 70° F., and then it reached only 70.3° F. August was a remarkably cool month, being only slightly warmer than September. The range of the temperature during the whole season was extremely favorable to the development of a beet of high character, and doubtless served to develop the conditions favorable to a very high coefficient of purity of the juice.

Meteorological data for Geneva, N. Y., 1903.

[Furnished by station.]

Month.	Temperature.	Precipitation.
	° *F.*	*Inches.*
May	60.3	0.23
June	63.2	7.77
July	70.3	4.86
Average and total	64.6	12.86
August	65.5	7.21
September	64.4	1.30
October	52	4.19
Average and total	60.6	12.70
General average and total	62.6	25.56

THE NEW YORK STATION AT ITHACA.

The only report received from the Ithaca station in regard to the details of the season's work was written under date of July 27, by the assistant agronomist, Mr. J. W. Gilmore, as follows:

The seed was planted on May 12. The last rain which was of material benefit to planted seeds or growing plants fell March 31 and April 1, so that by the

time the beets were planted the ground was quite dry on and near the surface, consequently the seed only partially germinated. The drought continued until June 12, and since that time we have had copious rains, too much rain, in fact, to give the best conditions of growth. After the rains set in the remainder of the seed germinated, but fortunately there were enough plants of the first germination to make a good stand for 50-foot portions of the row. Up to July 20 the beets had been thinned, weeded, and cultivated four times, and they are growing well.

The analytical data determined at the Bureau of Chemistry on the samples received from Ithaca are given in the following table:

Agricultural and analytical data on beets, grown at Ithaca, N. Y., and forwarded to Washington, D. C., 1903.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 9	7.6	.....	10.9	10.2	72.7
November 11	6.4	14.1	13.9	12.6	75.1
November 11[a]	4.1	.....	14.1	13.1	76.7
November 18	6.4	.....	13.9	12.8	76
November 23	5.7	12.6	13	12.1	74.3
Average	6	13.4	13.2	12.2	75

[a] Harvested October 19, 1903.

Although the station at Ithaca is not far distant from Geneva, quite a difference in the sugar content of the beets is noticed and also a marked difference in purity. The yield per acre at Ithaca was satisfactory. The same conditions of drought obtained during the early season as at the Geneva station. The amount of rainfall during May was only 0.3 inch, while for June and August it was excessive. October also was an extremely wet month, and consequently very unfavorable to the production of a beet of high character. The excessive rainfall in such cases tends to produce a second growth, which is largely at the expense of the accumulated sugar. During the season as a whole the cloudy days were in excess. The temperature at Ithaca was decidedly lower than at Geneva, July, the warmest month, having an average of only 67.4° F. August was a comparatively cool month, being only slightly warmer than September. In so far as the temperature conditions alone are concerned, they were decidedly favorable to the production of a beet with a high sugar content. No record of sunshine was kept at the Ithaca station, and the data for this factor of the environment are taken from the record of the Weather Bureau kept at Binghamton, N. Y., about 40 miles southeast of Ithaca.

Meteorological data for Ithaca, N. Y., 1903.

Month.	Temperature	Precipitation.	Clear days.	Cloudy days.
	°F.	Inches.		
May	57.6	0.30	16	6
June	60.8	5.67	2	19
July	67.4	2.64	7	18
Average and totals	61.9	8.61	25	43
August	63.6	7.15	3	17
September	61.6	1.21	11	9
October	50.6	5.69	3	18
Average and totals	58.6	14.05	17	44
General average and totals	60.2	22.66	42	89

Sunshine data for Binghamton, N. Y., 1903.

Month.	Sunshine.		
	Actual.	Possible.	Percentage.
	Hours.	Hours.	
May	338	451.9	75
June	129.5	456.2	28
July	247.2	461.8	54
Average			52
August	153.7	429.4	36
September	229	374.5	61
October	90	342.5	26
Average			41
General average			46

THE WISCONSIN STATION.

The first report on the experimental work at the Wisconsin Station was made by Mr. F. W. Woll, on July 20, as follows:

The land on which the beets are grown covers an area of 66 by 185 feet and adjoins the plat which was used for the sugar-beet experiments last year. The seed was sown on May 5, in rows 18 inches apart, 7 pounds of seed being used on the entire plat. The beets were up enough to show the rows on May 18, and were thinned June 3 and 4 to approximately 9 inches apart in the rows. The season has been very favorable to root crops up to this time, as we have had an abundance of rain and considerable cool weather. The stand on the plat is practically perfect, and the prospects for an excellent crop of beets are very good.

With the first sample of beets, on September 21, Mr. Woll reported on sugar content and yield as follows:

We analyzed the sample last week and found it rather low in sugar; so it is very likely that they have not improved much so far. With good clear weather for some time on they will, however, no doubt soon reach a fair sugar content, although, owing to attacks of rust on the beets from excess of moisture, they will not be apt to reach anything like the usual high percentage of sugar. The season this year has been extremely wet and cold, and all crops are more

or less behind. The weight of the 25 topped beets placed in the box is 27.55 pounds, and the calculated yield per acre, upon the basis of the beets dug in 50 feet of row, was 20.7 tons.

The final report from this station was received on November 2, after the harvest:

From the plat sowed 8.9 tons of beets were harvested. From the determination of the dirt in samples taken in different parts of the field, we found that the beets contained, on the average, about 4.5 per cent of dirt as weighed. The average per cent of sugar in the beet was 11.82, making the calculated yield of sugar per acre 3.1 tons.

As stated in my earlier letter, the past season was extremely wet and cold with us, and the beet field, being rather low, was submerged several times by water during the season after heavy rain storms. On account of the very wet season, rust attacked the beets and caused a large proportion of the old leaves to wither, thus reducing the sugar content of the beets, since the roots had to manufacture their sugar from a practically new set of leaves. Owing to the large yield of beets, however, which, as stated, amounted to over 26 tons to the acre, the yield of sugar was very satisfactory, viz, over 3 tons.

The analytical data determined at the Bureau of Chemistry on the samples received from Wisconsin are as follows:

Agricultural and analytical data on beets grown at Madison, Wis., and forwarded to Washington, D. C., 1903.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 25	13.4	21.12	12.3	11.4	81.4
October 2	13.4	15.35	12.6	11.7	79.7
October 9	15.6	----------	12.7	11.8	80.4
October 17	16	22.18	11.4	10.8	75.5
October 30	16	----------	13	12.4	78.3
Average	14.9	19.55	12.4	11.6	79

The data from the Wisconsin Station show a large yield of beets per acre, viz, 19.6 tons. The content of sugar in the beets was exceptionally low for this locality, viz, 11.6 per cent, and the purity fell below the standard of 80, which is regarded as being the minimum for the economical production of sugar.

The meteorological data show that there was a reasonably even distribution of the rainfall. Rather too much rain fell during May, viz, 4.38 inches, which probably interfered to some extent with the preparation of the seed bed and planting. July and August had rather excessive amounts of precipitation, but inasmuch as these are the warmest months, producing the greatest loss of water by evaporation, heavy precipitation at this time is less apt to produce injury than at the beginning or end of the season. The only month in which there was a deficiency of rainfall was June, which had less rainfall

than is advantageous to rapid growth. The temperature conditions observed are distinctly favorable for the production of a beet of good sugar content, and in this case there appears to be a lack of correlation between low temperature and high content of sugar rather more pronounced than in any case yet observed. The average temperature of July, however, was 71.2° F., which is rather high for that locality, but the temperatures for June and August were not excessively high. The rainfall in October was greater than is compatible with the proper ripening of the beets, and the excessive precipitation in August, combined with the rather high amount in September, are doubtless the features in the environment which tended to inhibit the storing of sugar by stimulating continued growth.

Meteorological data for Madison, Wis., 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	°F.	Inches.		
May	59.8	4.38	10	14
June	63.6	1.39	8	10
July	71.2	7.17	11	16
Average and totals	64.9	12.94	29	40
August	66.2	6.95	5	13
September	60.5	3.51	11	8
October	50.4	2.18	16	10
Average and totals	59	12.64	32	31
General average and totals	62	25.58	61	71

EXPERIMENTS CONDUCTED IN IRRIGATED SECTIONS.

THE CALIFORNIA STATION.

The experiment for 1903 at Pomona, Cal., was a failure, owing to the following causes: The beets were planted on March 14 and appeared above the ground on March 26, but the stand was not a good one. From April 25 to May 5 the beets were attacked by worms and the larger part of the plants were destroyed. The beets were thinned on June 1, but it was so apparent that any results obtained would be misleading that the work was abandoned and no analyses or weighings were made.

THE COLORADO STATION.

At the Colorado Station fertilized and unfertilized plats were grown and samples of beets from each have been analyzed, though no special study of the effect of fertilizers has been included in this investigation as a whole. The descriptions of the soil and fertilizers will be found on page 30. The beets were planted on April 27, and

thinned and weeded from May 30 to June 4. Under date of June 11, Mr. Danielson reported as follows:

The beets are growing well, and the seed sent by you has proved superior in vitality to any planted on the farm. The field planted with that seed has a better stand, with stronger plants, than the fields where double the amount of seed of other varieties was used. On July 3 and 23 the beets were irrigated.

On December 19 a further report was sent on the results obtained on plats E and F, giving the following data:

Analytical and agricultural data on beets grown at Fort Collins, Colo., determined at the station.

[Determinations on 12 beets, November 7.]

Plat.	Yield per acre (tare subtracted).	Average weight of beets.	Average weight of tops.	Weight of tops per 100 pounds of beets.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Tons.[a]	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	
F {No. 6, fertilized	21.5	[b] 2.04	0.68	33	16.8	15.1	85
F {No. 9, complete fertilizer used	20.6				17.9	16.1	87.9
E, not fertilized	19.8	1.67	.70	41	16.8	15.1	87.3

[a] Net weight, the tare having been subtracted.
[b] Average obtained on 352 beets was 1.25 pounds, tare subtracted.

A detailed report as to the stand and weight of beets is given below, and from these figures were calculated the tonnage as given, approximating closely the average figures reported by the station:

Stand of beets and weights on six successive dates.

FIELD E, UNFERTILIZED—50 FEET OF ROW.

	Sept. 26.	Oct. 6.	Oct. 10.	Oct. 17.	Oct. 23.	Nov. 3.
Number of beets in a row	54	58	49	60	66	58
Weight of 25 beets ..... pounds..	32	41	37.2	37	36	46
Weight of balance of row ..... do....	47.25	40	37.2	50	47	51
Total weight ..... do....	79.25	81	75	87	83	97
Estimated tonnage [a]	20.1	20.6	19.1	22.1	21.1	24.6

FIELD F, PLAT 6, FERTILIZED—50 FEET OF ROW.

Number of beets in a row	63	53	63	77	54	56
Weight of 25 beets ..... pounds..	38	36.5	45	29.5	40.7	44
Weight of balance of row ..... do....	40	39	47.5	54	40.25	47
Total weight ..... do....	78	75.5	92.5	83.5	84.95	91
Estimated tonnage [a]	20	18.8	23.5	21.2	21.6	23.1

[a] Average tonnage, 21.3.

The data determined on the samples received at the Washington laboratory are given in the following table:

Agricultural and analytical data on beets grown at Fort Collins, Colo., in 1903, as determined at Washington, D. C.

FIELD E, UNFERTILIZED.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 3	17.2		14.8	13.8	79.1
October 14	21.7		16.4	15.3	81.5
October 17	16.6		16.1	15.6	79.7
October 30	16.6		16.4	14.4	80.4
November 6	17.2		18.6	16.2	87.3
November 14	19.8		16	15.1	77.6
Averages	18.2	21.3	16.4	15.1	80.9

FIELD F, PLAT 6, FERTILIZED.[a]

October 3	20.1		16	14.8	82
October 14	19.2		17.9	16.7	83.6
October 17	24.4		16.7	15.7	81.1
October 30	13.4		19.6	18.5	81.6
November 6	20.1		18	16.2	85.3
November 14	20.1		18.3	15.9	81.7
Averages	19.5	21.3	17.7	16.3	82.5

[a] Experimental plat.

The temperatures and precipitation recorded at Fort Collins are given in the following table, but no sunshine data are available for a nearer point than Cheyenne, Wyo.[a]

Meteorological data for Fort Collins, Colo., 1903.

Month.	Temperature.	Precipitation.
	°F.	*Inches.*
May	52.2	0.63
June	59.3	2.23
July	68.4	1.06
Average and total	60	3.92
August	67.6	.86
September	56.8	.87
October	49.4	1.48
Average and total	57.9	3.21
General average and total	59	7.13

The meteorological conditions in Colorado were satisfactory, only two irrigations, on July 3 and 23, being required for the growth of the crop. The great advantage which is secured through irrigation in regions where there is but little if any rainfall, lies in the fact that the period of growth and maturity is attended by the use of the proper amount of water. Thus the dangers which come

[a] See page 27.

through the retardation of growth by drouth during the summer months or by the induction of second growth by rainfall in September or October are avoided.

The temperature conditions at Fort Collins, as will be seen by consulting the table, are very favorable to the production of a beet of a high sugar content. The early months of the growing season were somewhat cold; and even in July, the warmest month, the temperature was only 68.4° F. August was almost as warm, while in October the temperature fell again to a low point, 49.4° F. The precipitation, for an arid region, was quite heavy, being almost sufficient in June for the needs of the crop, while almost half as much water as the crop needed fell in July. August and September were both quite dry, but in October there was considerable rainfall (1.48 inches), but not sufficient to induce any dangerous second growth. The total precipitation for the growing months was 7.13 inches, which is probably one-half or more of the total amount of water required.

The yield per acre is high and the percentage of sugar in the beet entirely satisfactory, viz, 16.3 per cent, with a purity of 82.5.

A comparative test of the effect of fertilization on the composition of the beet was carried on at the Colorado station during this season. The effect of the fertilizer on the yield of the beets was practically nil, the tonnage being only slightly greater on the fertilized plats according to the data reported by the station and exactly the same according to the other figures given. In fact, it is at once evident that a soil with a natural fertility capable of producing 21 tons per acre could not be much benefited by fertilization. There was a distinct effect of the fertilizer on the quality of the beets, an increase of 1.2 per cent in sugar content and 1.6 in the purity coefficient being secured. The data in this case show a tendency on the part of the fertilizer used to improve the quality of the beet and not to increase the production. The improvement of the quality, however, is not of a character sufficiently marked to warrant the conclusion that fertilizers can be used for this purpose economically.

THE OREGON STATION.

At Union, Oreg., where the experiment was conducted for the first time in 1903, the season was very dry, and at first there was little certainty of a crop, although the heat was not extreme. The plat was subirrigated from a near-by stream. The seed was sown on April 29, the soil having been plowed to a depth of 8 or 9 inches in the preceding fall, and the young plants were thinned on June 1. They were cultivated twice with hoes and three times with a horse cultivator. Later in the summer the conditions became more favorable and a good tonnage was obtained. On October 14 the prospects

for further development seemed so adverse that the beets were then harvested, while not yet mature. Attention had been paid to the matter of breeding, with the intention of obtaining uniformity in the sugar content. It was also hoped that by this means a strain could be secured that would be immune from aphis. Seed from 38 beets of known sugar content were planted, and in the course of the year 12 mother beets having the desired properties were designated for propagation. The results of this scheme can not fail to be interesting. The data on the beets, as determined at the Bureau of Chemistry in Washington, showed that the average weight per beet was 14 ounces, the estimated yield per acre 18 tons, the amount of sugar in the juice 19.8 per cent and in the beet 15.8 per cent, and the purity coefficient 88.3.

The data from Oregon are interesting in this respect, namely, that they belong to a region which has produced beets of phenomenal richness. Just what the conditions of the environment are in Oregon and Washington which have caused the growth of beets so rich in sugar it is difficult to determine. Probably many of the reported data concerning beets of this extraordinary quality are based on the analysis of abnormal samples or are obtained by methods not strictly controlled. Nevertheless, the fact remains and is confirmed by the data here submitted that the beets which are produced in this region are remarkably rich in sugar.

An inspection of the meteorological data reveals at least a presumptive reason for this condition. It is seen that the temperature conditions are remarkably uniform, varying but little during the whole season, from May to October, inclusive. The maximum average monthly temperature for the season was in August, and it is only 65.2° F. The minimum temperature occurred in October, when it fell to 49.6° F. The average temperature for June, July, and August was 4° below the standard of 70° F., which is regarded as the maximum compatible with the development of beets sufficiently rich in sugar to justify the establishment of factories. It appears, therefore, from a preliminary study of the environment of this region that the most important factor in the production of beets rich in sugar is found in the low temperature of the summer months.

The record of precipitation shows that the rainfall is not sufficient for the production of a crop, although the rate of evaporation must be low by reason of the low temperature. The beets were therefore subirrigated by the utilization of water from a near-by stream.

The number of clear days is remarkably high, showing an abundant supply of unobstructed sunlight. This is a condition which is not objectionable, provided the temperature remains low. The data regarding the growth of beets in these regions are still too fragmentary to permit of formulating definitely any statements respecting the influence of other features of the environment.

Meteorological data for Baker City,[a] Oreg., 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	51.2	0.49	10	10
June	64	1.29	7	12
July	62.8	.21	16	3
Average and totals	59.7	1.99	33	25
August	65.2	.87	23	3
September	54.3	1.06	13	11
October	49.6	1.14	14	11
Average and totals	57	3.07	50	25
General average and totals	58.4	5.06	83	50

[a] About 27 miles south of Union.

THE WYOMING STATION.

On July 27, Mr. Nelson, assistant in agronomy of the station at Laramie, reported as follows:

The plat is in good condition. The stand is good, and the plants had leaves about 6 inches long July 23, when examined. They had been properly thinned, hoed, and weeded, and were, on the whole, in as good a condition as could be expected.

The data determined at the Bureau of Chemistry show that the average weight of the beets after topping was 16 ounces, and the yield (reported by the station) 7 tons per acre; the percentage of sugar in the juice, 12.9; that in the beet, 11.8; and the purity coefficient, 69.4. The meteorological data are given in the following table:

Meteorological data for Laramie, Wyo., 1903.

Month.	Temperature.	Precipitation.	Sunshine.[a]			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	43.9	1.63	268.4	449.1	60	15	5
June	53.9	1	251	451.9	56	17	2
July	62.6	1.31	291.8	458.6	64	18	4
Averages and totals	53.5	3.94			60	50	11
August	63.4	.88	288	427.4	67	22	0
September	51.2	2.39	250.4	374	67	17	5
October	43.4	.50	259.3	343.9	75	22	4
Averages and totals	52.7	3.77			70	61	9
General averages and totals	53.1	7.71			65	111	20

[a] Data for Cheyenne, about 45 miles southeast of Laramie.

The data from Wyoming are extremely fragmentary, and are only given tentatively as perhaps a foundation for future studies. Here we find a poor showing in respect of the richness of the beets, but the data are insufficient to make clear the principal factors of the environ-

ment which have been most active in depreciating the quality. It may be that in this case the temperature is too low for proper growth. It will be seen by a glance at the meteorological table that the warmest month is August and the average temperature is only 63.4° F. May was almost like a winter month, the temperature reaching only 43.9°, while June had an average temperature of only 53.9° F. These data show that there was scarcely heat sufficient to produce mature beets, and are quite in contrast with those for Oregon, where, especially at the beginning and end of the season, it was much warmer than in Wyoming.

Under date of June 16, 1905, in answer to a letter of inquiry sent by the author, Director Buffum made the following comments on beet growing in Wyoming:

Your statements about weather conditions are correct. Our seasons are short and cold and we do not get sufficient tonnage to make the beet crop profitable. Perhaps this can be overcome by breeding beets suitable for this soil and climate. You will find in past experiment station bulletins that we finished our beet investigations some years ago, coming to this conclusion. There are several sections of Wyoming at lower altitudes where sugar beets are a very satisfactory crop and where other conditions are suitable for sugar factories. Our beets are always raised under irrigation.

THE SOILS.

The following data descriptive of the soils on which the beets were grown in this year were received from the stations:

DESCRIPTIVE NOTES ON THE UNIRRIGATED SOILS.

AMES, IOWA.

The plat upon which the beets were grown in 1903 was in grass in 1897. It was plowed in the fall of that year and sown to winter wheat. Upon the removal of the wheat the soil was manured and sorghum was sown in 1899, followed by oats in 1900 and spring wheat in 1901. In 1902 a crop of sugar beets was harvested.

The soil is a black loam about 22 inches deep, underlain with a stiff yellow clay, which is full of carbonates. This soil is classified as a normal soil, requiring no special treatment.

LAFAYETTE, IND.

Prior to 1897 the crops grown were wheat, beets, and corn. In 1897 and 1898 the crop was beets. The history for the year 1899 is unknown. In 1900 the land was heavily manured and corn was grown. Soy beans were planted in 1901 and plowed under in the fall. In the year previous to the experiment the plat had been sowed with sugar

beets, but, owing to the failure of the crop, the land was summer fallowed. In March, 1903, the plat was plowed and harrowed, and reharrowed in May.

LEXINGTON, KY.

The beets were grown on the same rich, loamy soil on which this work has been conducted in previous years, known as "blue-grass" soil.

THE MICHIGAN STATION.

The following history of the plat used is given in connection with the soil analysis and the work of other years, though no beet analyses were obtained for 1903:

The plat selected for the experiment was a sandy loam, which had borne crops in years preceding as follows: In 1899, oats; in 1900, sugar beets; in 1901 it was seeded to clover without a nurse crop; in 1902, clover again. The ground had been subsoiled for the beets in 1900.

GENEVA, N. Y.

The field was sown to alfalfa in 1890 and this crop continued for five years. Crops were cut from three to four times each season for green forage or hay. In the fall of 1895 the field was plowed and sown in rye. In the spring of 1896, when rye was fully headed, it was plowed under and the ground was seeded again to alfalfa. This crop remained until the spring of 1901, when the alfalfa stubble was turned under and the field was planted in corn. This crop was followed in the spring of 1902 with barley. In the fall of 1902 the field was plowed and remained in the furrow until the following spring. The ground was plowed from 11 to 12 inches deep just before sowing the beets, but not subsoiled.

The soil was a clay loam varying from medium to quite heavy. The field from which these plats were taken is rolling, this portion broken up by a narrow "dip" extending nearly at right angles across the plats, running from north to south. A very slight loss in yield resulted from the washing by surface water after heavy showers on this portion of the plats. As the ground rises to the east of this "dip" it is heavier than that to the west.

ITHACA, N. Y.

At Ithaca the plat used was practically the same as that of the preceding year, and therefore the same data are applicable. The soil is a sandy loam of good depth and fertility.

BLACKSBURG, VA.

The following detailed comments on the soil sampling were sent by Mr. H. L. Price:

First opening.—A good average spot on the best part of the plat. Top soil 10 inches deep; line of demarcation between this and subsoil quite distinct. Top soil brownish black in color and contains considerable humus. Subsoil a sticky yellow clay, homogeneous, firm, and quite retentive of moisture. Contains no rock or pebbles. The total depth is 18 inches.

Second opening.—West end of plat. Top soil still a rich loam, practically the same as above, but a little lighter color; 9 inches deep. Line between top and subsoil clearly defined. Subsoil pale gray with ocherous tint; made up of silt and clay, free from pebbles.

This plat of land was planted to garden crops last year, and received frequent cultivation during the growing season. No manure or other fertilizer has been applied since the spring of 1902. In the spring of 1903 the ground was plowed very deep, but a subsoiler was not used.

MADISON, WIS.

The soil on which the beets were grown during 1903 is a clay loam with a heavy clay subsoil. A part of the field was in sugar beets in 1902 and in rape and peas in 1903. This field has been in cultivation for the past thirty years at least, and has been brought up to a high state of fertility through the application of barnyard manure and by pasturing sheep and swine in different seasons during the past twelve years or more.

DESCRIPTIVE NOTES ON IRRIGATED SOILS.

POMONA, CAL.

The beets were grown on a sandy soil, the analysis of which is given as a matter of record, though the crop for 1903 was a complete failure.

COLORADO STATION.

At Fort Collins, Colo., the beets were cultivated in fertilized and unfertilized plats. The history of these plats was given by Mr. A. H. Danielson, as follows:

Plat F (fertilized) had an application of land plaster three years ago. The crop in 1901 was beets; in 1902, grain; and in 1903, beets again. Plat E (unfertilized) had a heavy application of stable manure three years before the experiment. The crop for the year previous to the experiment was grain, and for the two years preceding that corn was grown.

The results of the experiment with fertilizers were embodied by Mr. Danielson in the following report:

The subject of sugar-beet growing is now greatly interesting to Colorado. It has increased until it is an important industry on a commercial basis. The

farmer's great interest lies in getting the most beets from his land. For this purpose he uses the powerful fertilizing effect of alfalfa, or barnyard manures, or when the supply of manures decreases he must in time turn his attention to commercial fertilizers, as older beet-raising sections have done. For this reason we have conducted some experiments, in order to be ready with information in time to be of use to the farmers in this section. Results as derived in humid climates are of little use to us, under arid conditions and irrigation. A little pioneer work will tell us in what direction to pursue experiments of like nature in the future. The past season's work in this line was carefully performed on three different fields. We believe the results give decided indications of what materials to use and what not to use. Our results are nearly ready to be published in detail should it be desirable to do so, but a few of the main conclusions from one season's work may here be briefly stated.

Nitrate of soda was the most effective among the commercial fertilizers. Five to six dollars' worth, or 150 pounds per acre of nitrate, increased the yield of beets over 4 tons per acre, worth over $20 at $5 per ton. Nitrate of soda used alone, however, lowered the sugar content and purity 1 to 2 points. Nitrate of soda used alone produced a better yield than 30 tons of cow manure per acre; 150 pounds of nitrate of soda and 15 tons of cow manure per acre produced a little better yield and more sugar per acre than 30 tons of cow manure per acre used alone. An excessive quantity of cow manure, or 60 tons per acre, made less yield and less sugar than 30 tons per acre. The shape of the beets was also poor with the larger quantity. Nitrate of soda with cow manure did not lower the purity as much as nitrate alone. One hundred and fifty pounds of nitrate of soda and 200 pounds of bone meal together made more sugar per acre, with higher purity, than nitrate alone. Phosphate fertilizers, as bone meal and basic slag, had little or no effect. So-called "complete fertilizers," with potash, had little or no effect. Complete fertilizers with the nitrogen from nitrates were more effective than the same with nitrogen from other sources. The plats were one-tenth acre in area; the yield ranging from 20.63 tons to 25.67 tons per acre in one field, and from 24.92 tons to 27.88 tons per acre in another.

The best results were obtained by mixing the fertilizers with the soil before planting the seed; fertilizers applied on top of the soil after the beets were up had no effect. In the case of nitrate of soda so applied the effect was positively injurious, decreasing the yields about 3 tons per acre and retarding the growth of the beets.

UNION, OREG.

At Union, Oreg., a plat was used which had been planted in sugar beets the preceding year. The soil was a dark loam, subirrigated from a near-by stream.

LOGAN, UTAH.

The plat used for the experiment in Utah was fertilized in January with well-rotted stable manure at the rate of 15 tons per acre, and was plowed 10 inches deep in April, about a week before the sowing.

ANALYSES OF SOILS.

In the following tables are given analyses of the soils used in these experiments:

Chemical analyses of soils used in the sugar-beet experiments of 1903.

[Percentages based on water-free soil.]

UNIRRIGATED SOILS.

Serial No.	Locality.	Description.	Insoluble.	Volatile.	Nitrogen (N).	Soluble in hydrochloric acid of 1.115 specific gravity.				
						Potash (K_2O).	Lime (CaO).	Magnesia (MgO).	Fe_2O_3, Al_2O_3, and Mn_3O_4.	Phosphoric acid (P_2O_5).
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
2133	Lafayette, Ind	Soil	82.74	6.86	0.203	0.38	0.43	0.43	8.43	0.11
2134	do	Subsoil	80.48	6.83	.163	.39	.54	.37	10.57	.07
2135	Ames, Iowa	Soil	82.06	9.29	.266	.27	.78	.22	7.03	.085
2136	do	Subsoil	85.63	5.99	.147	.18	.78	.30	7.66	.03
2147	Lexington, Ky	Soil	82.96	6.93	.238	.50	.54	.18	8.79	.51
2148	do	Subsoil	85.41	4.61	.127	.29	.45	.21	8.54	.11
2153	Agricultural College, Mich.	Soil	92.24	3.38	.098	.12	.36	.25	3.23	.08
2154	do	Subsoil	94.69	1.55	.014	.10	.36	.29	3.35	.03
2149	Geneva, N. Y	Soil	86.57	4.82	.147	.44	.51	.68	7.05	.09
2150	do	Subsoil	84.95	4.18	.070	.60	.51	.71	8.91	.08
2143	Blacksburg, Va	Soil	87.90	4.55	.112	.29	.16	.09	6.76	.13
2144	do	Subsoil	80.89	4.63	.021	.44	.22	.37	13.22	.04
2139	Madison, Wis	Soil	86.86	6.70	.182	.23	.58	.14	4.94	.14
2140	do	Subsoil	88.76	4.10	.088	.14	.47	.25	6.21	.11
2141	Washington, D. C	Soil	84.25	5.40	.140	.27	.45	.32	9.13	.10
2142	do	Subsoil	84.66	5.49	.126	.24	.42	.30	8.75	.08
		IRRIGATED SOILS.								
2145	Pomona, Cal	Soil	84.85	1.82	0.021	0.48	1.58	0.96	9.45	0.14
2146	do	Subsoil	85.05	2.25	.028	.47	1.60	.96	9.25	.15
2155	Fort Collins, Colo	Soil (F)	76.48	7.40	.175	.93	3.30	1.18	10.25	.16
2156	do	Subsoil (F)	73.21	10.94	.112	.60	4.38	1.37	9.09	.14
2157	do	Soil (E)	81.59	4.97	.140	.85	1.28	.67	9.92	.11
2158	do	Subsoil (E)	77.87	6.00	.105	1.06	.90	1.36	12.88	.09
2137	Union, Oreg	Soil	71.23	11.90	.343	.52	2.75	.48	12.97	.04
2138	do	Subsoil	73.66	9.10	.210	.41	2.14	.63	13.74	.07
2158	Laramie, Wyo	Soil	82.50	4.57	.112	.78	.75	.93	9.79	.10
2152	do	Subsoil	80.68	5.86	.070	.67	2.53	1.08	9.04	.10

Yield of beets and soil data, 1903.[a]

UNIRRIGATED SOILS.

Station.	Yield per acre.	Chemical analysis.		
		Potash.	Nitrogen.	Phosphoric acid.
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*
Lexington, Ky	6.3	0.40	0.183	0.31
Lafayette, Ind	8.9	.38	.183	.09
Ithaca, N. Y	13.4	.44	.12	.14
Washington, D. C	14.6	.25	.133	.09
Ames, Iowa	15.6	.22	.206	.06
Geneva, N. Y	15.6	.52	.109	.085
Madison, Wis	19.6	.19	.135	.13
IRRIGATED SOILS.				
Union, Oreg	14	0.42	0.277	0.06
Laramie, Wyo	16	.73	.910	.10
Fort Collins, Colo	20.8	.67	.144	.15

[a] Averages of figures for soil and subsoil are given.

It is evident that no valuable comparison can be made of yield with the composition of the soil unless all other conditions of the environment are exactly the same. The analytical data, therefore, must be regarded rather as an indication of the potential capabilities of the soil than as an expression of their direct relation to the production of any particular crop.

In respect of potash soluble in hydrochloric acid (1.115 sp. gr.), it is seen that the soils from Geneva and Lexington contained the largest quantities, while those from Michigan and Wisconsin contained the smallest quantities. There is evidently a deficiency of potash in the soils last mentioned. Lime is an important factor in soils as affecting their physical texture and progress of nitrification. The extensive data which have been collected relative to the analysis of American soils show that lime is usually deficient in quantity. This accounts for the very common occurrence of acidity in our soils. Of the soils examined, those from Iowa, Wisconsin, Kentucky, and Geneva, N. Y., have the largest quantities of lime, while those from Virginia and Michigan have the smallest. None of the soils examined is remarkably rich in phosphoric acid except that from Lexington, Ky. The others only have the minimum quantity necessary for the production of a series of large crops, and it is probable that most of them would be benefited by an application of phosphatic material. As regards nitrogen, the soils, as a rule, have larger quantities than the subsoils, due, doubtless, to their larger content of organic matter. The samples from Indiana, Iowa, Kentucky, and Wisconsin have the largest quantities of nitrogen, while those from Michigan and Virginia have the smallest. The soil at Washington has almost the same quantity of nitrogen in the soil and subsoil, and this is explained by the fact that it was artificially formed, as already described.

The irrigated soils are all very rich in potash, and, since potash salts as a rule are quite soluble in water, it is evident that a soil which is infrequently leached by water would, other things being equal, have a larger quantity of potash than the soil from a wet region. The same remarks may be made as to the lime content of the irrigated soils, which is in some instances ten times as great as in the nonirrigated soils. The average amount of phosphoric acid in the irrigated soils is almost exactly the same as in the nonirrigated soils. This is partly due to the comparative insolubility of the phosphates of lime, alumina, and iron in water. The content of nitrogen in the irrigated soils varies greatly. There is scarcely any in the sample from California, while the soil from Oregon contains a very large quantity.

As has already been stated, it is not advisable to attempt to compare the fertility of soils as shown by chemical analysis with the magnitude of the crop, unless the other conditions of environment

are all strictly alike. The table, therefore, which gives the yield per acre, together with the content of principal plant foods of the soil, must not be too literally construed. Inasmuch as the roots of plants penetrate also into the subsoil, the data in this table are expressed as the average content of the ingredient mentioned in the soil and subsoil in each case. In general it may be said, as has been noticed in the previous experiments, that the soil has probably less to do with the chemical composition of the beet than any other factor of the environment. Under proper meteorological conditions, however, the soil is the chief factor in determining the magnitude of the crop.

SUMMARY OF DATA FOR 1903.

In the following tables are summarized the agricultural, chemical, meteorological, and geodetic data relating to the experimental work with sugar beets in 1903:

Summary of agricultural and analytical data, 1903.

WHERE IRRIGATION WAS NOT USED.

Station.	Mean weight of topped beets.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Washington, D. C.	18.9	14.6	8.7	71.6
Lexington, Ky.	11.9	6.3	9.5	72
Madison, Wis.	14.9	19.6	11.6	79
Ithaca, N. Y.	6	13.4	12.2	75
Lafayette, Ind.	14.9	8.9	13.2	81.6
Geneva, N. Y.	11.6	15.6	14.2	89.4
Ames, Iowa	13.2	15.6	15.5	81.8

WHERE IRRIGATION WAS USED.

Laramie, Wyo.	16		11.8	69.4
Fort Collins, Colo.	20.8	21.5	15.1	85
Union, Oreg.	14	18	15.8	88.3

Summary of meteorological data, May to October, 1903.

WHERE IRRIGATION WAS NOT USED.

Station.	Temperature.	Precipitation.	Clear days.	Cloudy days.	Sunshine.
	° *F.*	*Inches.*			*Per cent.*
Washington, D. C.	67.2	21.26	81	53	57
Lexington, Ky.	68.8	11.50	80	38	62
Madison, Wis.	62	25.58	61	71	
Ithaca, N. Y.	60.2	22.66	42	89	[a] 46
Lafayette, Ind.	65.9	17.35	82	89	[b] 58
Geneva, N. Y.	62.6	25.56			
Ames, Iowa	63.6	22.43	105	29	[c] 60

WHERE IRRIGATION WAS USED.

Laramie, Wyo.	53.1	7.71	111	20	65
Fort Collins, Colo.	59	7.13			[d]
Union, Oreg. [e]	58.4	5.06	83	50	

[a] Sunshine data for Binghamton, N. Y.
[b] Sunshine data for Indianapolis, Ind.
[c] Sunshine data for Des Moines, Iowa.
[d] See Laramie.
[e] Data for Baker City, Oreg.

Geodetic data.

WHERE IRRIGATION WAS NOT USED.

Station.	Average length of day.	Latitude.	Altitude.
	h. m.	° ′ ″	Feet.
Washington, D. C	14 23	38 53 23	37.5
Lexington, Ky	14 18	38 02 25	979
Madison, Wis	14 44	43 04 36	955
Ithaca, N. Y	14 41	42 27 00	810
Lafayette, Ind	14 30	40 23 00	542
Geneva, N. Y	14 44	42 53 00	453
Ames, Iowa	14 38	42 02 00	917

WHERE IRRIGATION WAS USED.

Laramie, Wyo			7,130.5
Fort Collins, Colo	14 32	40 35 00	4,994
Union, Oreg			2,789.6

CONCLUSIONS.

The general effect of the environment is represented by charts constructed on the same plan as that followed in the three previous reports. Chart No. 1 is a graphic illustration of the amount of sugar in the beet, the percentage of sunshine during the period of growth, the number of clear days in the month, and the latitude of the several stations. In general, it will be seen that the content of sugar in the beet varies with the latitude, the lowest sugar content in the lowest latitude, and vice versa. While, as is to be expected, there are variations in this curve, the general statement that the content of sugar rises as the latitude increases is again established. There is a less definite relation between the hours of sunshine and the sugar content of the beet. Inasmuch as it is generally conceded that the formation of sugar in the plant is a function which is largely influenced by light and can not be conducted without it, it seems only reasonable to suppose that the greater the quantity of light the greater the quantity of sugar developed. It is evident, therefore, that as the latitude increases the number of hours of light increase, thus giving the plant laboratory a longer working day. It has also been pointed out that light is more important than clear sunshine, since those radiations of the sun which are most active in stimulating the cellular activity of plants seem to suffer no marked diminution of power in passing through strata of aqueous vapor. The number of clear days varies greatly at the different stations; there was the lowest number at Ithaca, while Washington, Lexington, Lafayette, and Ames all had a very large number of clear days in proportion to the number of days in the month.

In chart No. 2 appear curves representing the percentage of sugar in the beet, the purity of the juice, the average monthly temperature

at the stations named, and the average length of day at these stations. This chart shows in a very decided manner the intimate relation between the percentage of sugar in the beet and the length of day. There are some apparent exceptions to this rule, but in general the agreement is close. The purity of the beets, as might be expected, bears a very close relation to the quantity of sugar in the beet. The curve representing the temperature, as in former investigations, shows that as a rule the temperature varies inversely as the sugar content of the beets, being highest when the sugar is lowest and lowest where the sugar is highest. The irregularities of this curve are more pronounced in the present chart than in any of those appearing in previous reports during which the investigation has been conducted.

Chart No. 3 is a graphic comparison of the percentage of sugar in the beet, the total rainfall during the season at the various stations, together with its distribution by months, and the altitude of the stations. There is a general agreement shown between the percentage of sugar in the beet and the altitude of the station, but this agreement is not uniform, and it is evident that the only effect of the altitude will be found in diminishing the temperature and that otherwise it can not have any possible effect upon the composition of the beet. There is an apparent relation between the amount of rainfall and the sugar content, the curves rising together, but this may be regarded as an indication of no value, but rather as accidental, and, moreover, there are wide and violent variations from the general agreement. The distribution of the rainfall appears to have had no direct effect upon the content of sugar in the beet. It is evident, however, that there might be such a distribution of the rainfall as to influence unfavorably the sugar content, and this has been pointed out in the discussion of the data of the various stations. There would be undoubtedly a tendency of the rainfall to diminish the sugar content if it should be so distributed as to restrain the normal growth of the beet during the growing period, especially in August, or to unduly stimulate it by excessive rainfall during the period would naturally take place, as in September and October. A number of instances of this kind have been already pointed out.

The data for the year 1903 are less decisive and less complete than for any other year, but are placed on record as of comparative value in connection with those secured during the other years of the cooperative experiment.

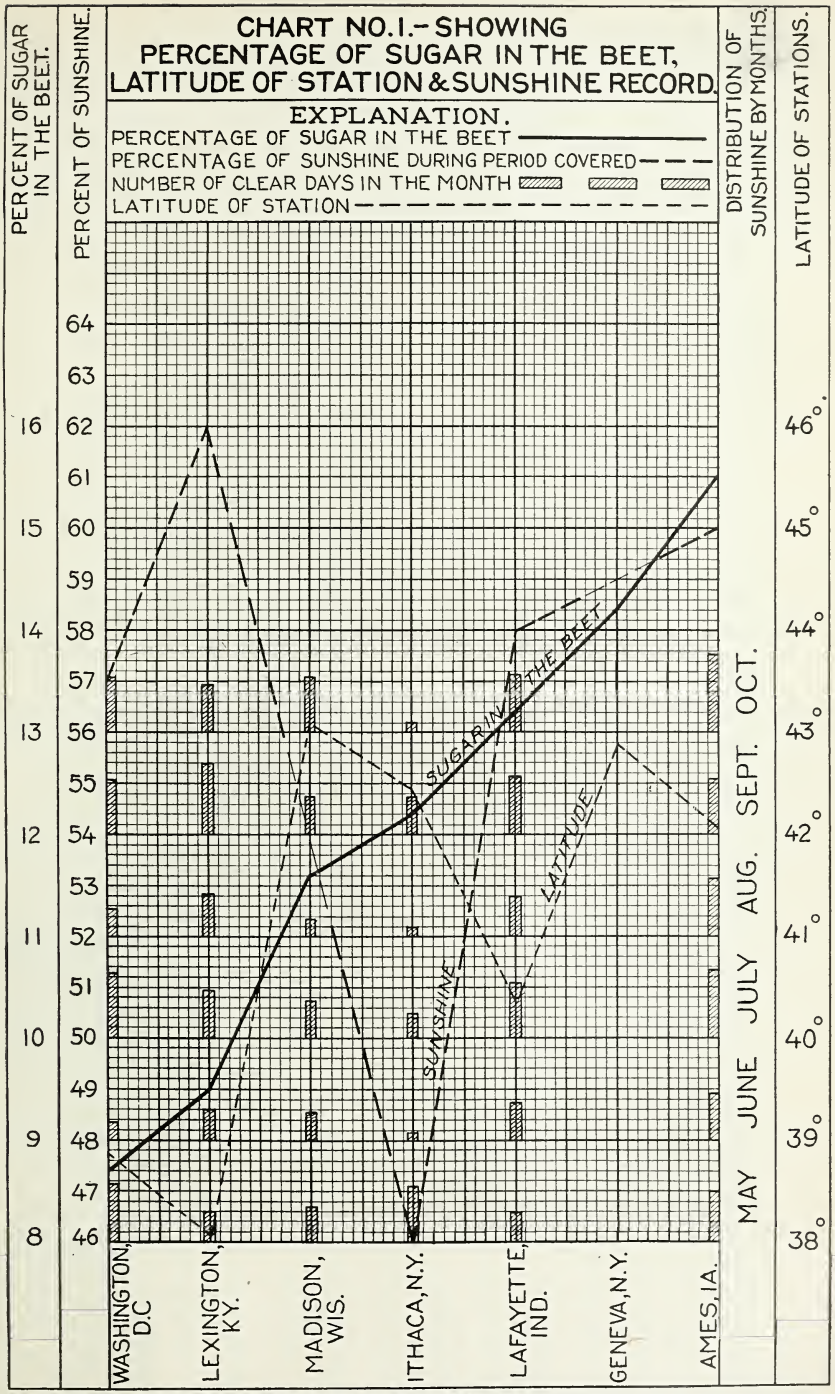

FIG. 1.—Sugar content of the beet as influenced by the amount and distribution of sunshine and the latitude of the station.

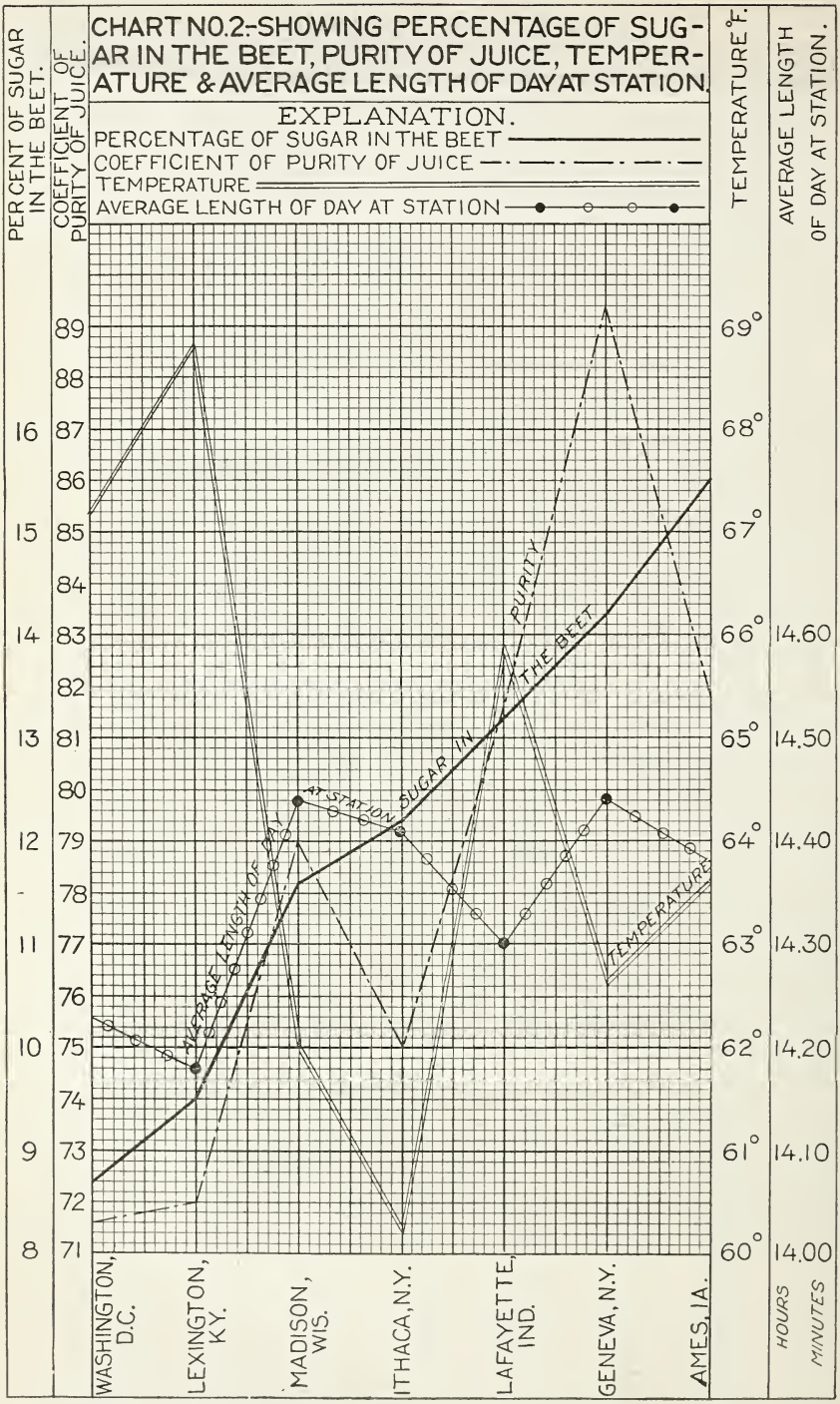

FIG. 2.—Sugar content of the beet compared with the purity and the temperature and average length of day at the various stations.

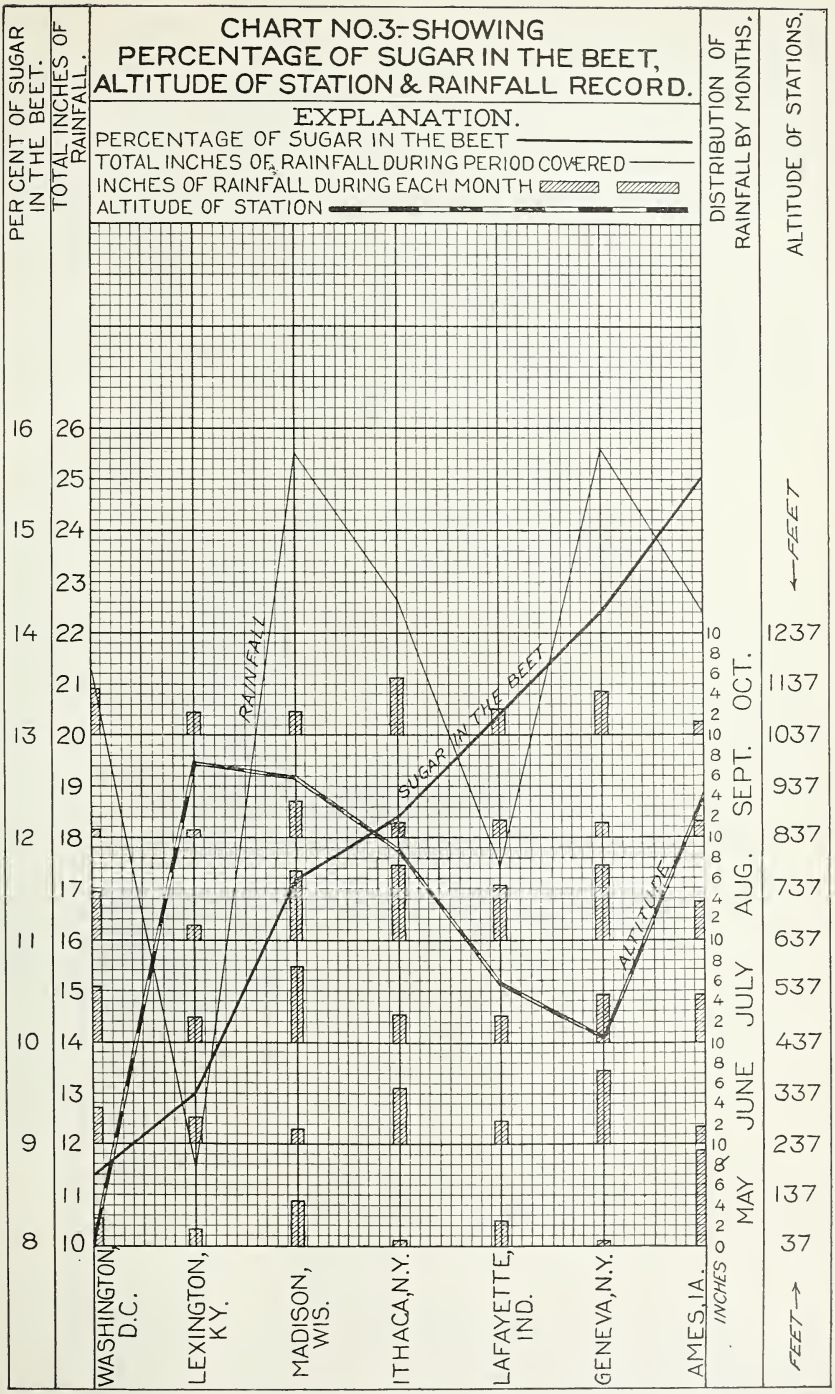

FIG. 3.—Sugar content of the beet as influenced by the amount and distribution of rainfall and the altitude of the station.